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Exploring the stimuli for customers in Bavaria aged 18-34 years to opt for both high-speed and conventional rail regarding holiday travels

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Abstract: This article aims at promoting the use of trains for holiday travels. Data were gathered in July 2024 in Passau. After selecting differentiating factors by employing independent-samples proportions z-tests, t-tests of symmetric distribution based on skewness, and asymptotic independent-samples z-tests, probit analyses and binary logistic regressions were utilised. Based on a sample consisting of 179 participants aged 18-34 years, rather plant-based nutrition, geographically close destinations (with particular reference to the sample, the DACH region), bicycle as one of the transport modes during holiday travels, opting for rail for business trips, and the use of voluntary carbon offsets are enablers without financial implications for the railway operators. Contrary to them, relying on car is mitigating the chance that rail is selected for holiday travels. Regarding the measures with financial implications for the service providers, evaluating favourably both the rolling stock (in terms of comfort, hygiene, privacy, moving with luggage, and emissions impact) and the elements of flexibility associated with rail transport, furthermore, supporting loyalty programmes are likely to result in customer preferences for rail.

Keywords: *high-speed rail, international travel, holiday travel, passenger transport, sustainability*

JEL Codes: *L92, O18, Q01, R41*

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Introduction

Infrastructure is one of the main pillars of modern societies and thriving economies. By creating and maintaining the current framework of transport, human activities represent severe threats to nature even if mankind strives to mitigate its environmental load. Numerous cities around the globe are part of multimodal networks consisting of both railway stations and airports enabling an enhanced connectivity of the settlements and intermodality during travel. In Europe, most tourist destinations are served by rail and plans to expand the railway networks and create further cross-border links exist (see e.g. infrastructure projects related to European Transport Corridors). The future trans-European transport network can be created inter alia by increasing the travel speed on major passenger railway lines, promoting the air-to-rail modal shift through long-distance rail, and building the infrastructure for alternative fuels (EC, 2025a). High-speed trains (HSTs) proved to be real and more climate-friendly alternatives to short-haul aviation up to 800 km (see the connection between Paris and Marseille) due to their competitive speed, routes between centrally located railway stations, and both the energy intensity (MJ/passenger-kilometre) and greenhouse gas (GHG) emission intensity (g CO_2-equivalent/passenger-kilometre) (IEA, 2019, 2023). Imposing taxes for and bans on flights, relying on air–rail competition as a market instrument, and the European Union's (EU's) liberalisation of the commercial long-distance passenger-rail market can foster not only the penetration of public transport by reducing car use, but the air–to–rail modal shift as well (Dalla Chiara et al., 2017, p. 240; EUR-Lex, 2012). Albeit the high-speed rail (HSR) network[2] in the European Union is continuously widening, the share of aviation based on the modal split of passenger transport is likely to keep growing. In 2024 in the EU for rail transport, international journeys accounted for less than 6% of national journeys in terms of total passenger-kilometres. Both passenger and freight transport performed by rail could gain ground by unburdening roads. The number of deceased persons in railway transport

[2] In 2023, dedicated HSR lines with a maximum speed of 250 km/h or more were established in Spain, France, Germany, Italy, Belgium, the Netherlands, Denmark, and Turkey. This circle can be widened if only upgraded HSR lines are considered: Sweden, Finland, Poland, Austria, Switzerland, and Norway. The total share of upgraded and dedicated HSR lines was 45.6%+10.0%=55.6% in France, while the other paragon in expanding its HSR network was Spain with a ratio of 4.6%+19.8%=24.4%, respectively (Eurostat, 2025a, 2025c). Hungary is not affected.

accidents is a slight fraction of the road fatalities (Eurostat, 2025a, 2025b, pp. 11, 16, 20, 23, 37, 39).

Germany has one of the highest population densities (approx. 240 persons/km^2) and one of the densest national railway networks (109.5 metres of railway line per km^2 in 2023). These favourable circumstances enable the country, demonstrating bold environmental commitments, to be appropriate for an investigation providing valuable results (EC, 2025b; World Bank, 2025a, 2025b). The share of travels abroad was 41% in 2023 by visiting primarily Austria, Italy, Spain, the Netherlands, and France (Destatis, 2024a). GHG emissions stemming from passenger and freight transport by rail are disproportionately low compared to those produced by aviation, navigation, or motorised individual transport on roads (Destatis, 2024b). In 2023, car was used in 58% of travels despite its typical GHG emission intensity, train accounted for 19%, aeroplane had a share of 16%, and the rest divided amongst other travel modes (e.g. coach and ship). In 2024, the national railway operator DB carried 1.9 billion passengers, thereof 105.6 million (5.7%) used HSR, i.e. Intercity-Express (ICE) and 26.1 million (1.4%) opted for IC or Eurocity (EC), resulting in a general capacity utilisation of long-distance trains amounting to 47.0%. The average travel distance was 362.1 km for ICE and 222.5 km for IC/EC. Regarding transport performance, the respective shares are 45.1% for ICE and 6.9% for IC/EC. DB set a long-distance transport performance target exceeding 70 billion passenger-kilometres per annum corresponding to an accrual of 59% compared to 2024 (DB, 2025a, pp. 2, 16, 18).

This research primarily attempts to scrutinise the travel preferences and further characteristics of those customers living in Bavaria, aged 18-34 years, who opt for HSR and/or conventional rail when making both domestic and international holiday travels. The objective is to spur a reasonable modal shift from travel modes with high GHG emission intensity (i.e. traditional car and short-haul aeroplane) towards rail in the case of parallel availability.

Literature review

Open-access articles meeting multiple search criteria (recorded in the database offered by the Web of Science Core Collection, dealing with one of HSR, HSTs[3], and long-distance or international train/travel, published be-

[3] Research related to the COVID-19 pandemic, freight transport, technical issues, and similar topics was disregarded.

tween 2006 and 2025, written in English, showcasing results valid for Europe) formed the initial basis of the simplified systematic literature review. This circle was complemented with studies about youth tourism in the context of sustainability. Selected works from the synthesised union of relevant articles and topics with overlapping dimensions are presented below:

1. **HSR passengers**: inventorying customer preferences, identifying passenger profiles, measuring and improving the level of satisfaction with HSR services based on passengers' feedback (Güner et al., 2024), exploring determinants of travel behaviour related to HSR by hinting at demographic and travel characteristic differences in attitudes (Harvey et al., 2014, p. 75), estimating the value of travel time savings,
2. **economic and social impacts**: analysing spatial impacts of HSR extensions in terms of efficiency and equity (Monzón et al., 2013, pp. 24-28), the contribution of HSR services to tourism or population growth, effects of the HSR infrastructure on social cohesion, promoting regional development e.g. spatial integration (Pařil & Viturka, 2020),
3. **environmental impacts** (e.g. carbon emissions, ecosystems): studies quantifying the environmental burdens of HSR (loss of landscape structural connectivity) (Martín et al., 2021), the environmental balance of HSR projects by means of a Life Cycle Assessment (encompassing the construction, operation, and maintenance of the infrastructure coupled with vehicle manufacture, operation, maintenance, and disposal) (Kortazar et al., 2021, p. 3),
4. **launching HSR projects, grounding the foundation of a HSR network and its expansion**: estimating the number of users of HSR, forecasting demand or the planned expansion of HSR based on the catchment area of stations (Naranjo Gómez et al., 2020, p. 3), suggesting a framework to determine the optimal timing to invest in HSR, evaluating HSR projects based on a cost-benefit analysis (De Rus, 2011), collecting main concerns of HSR projects regarding their impact on mobility, the environment, the economy, and urban centres (Albalate & Bel, 2012, pp. 343-346), analysing scenarios for an improved European HSR network being part of the trans-European transport network (Grolle et al., 2024), applying HSR as an instrument for promoting economic integration, decision-making process related to HSR investments (Hermelin & Gustafsson, 2021),
5. **transport market with main focus on the interaction between aviation and HSR**: scrutinising the modal substitution from air (short-haul

flights) to HSR (Avogadro et al., 2021; Reiter et al., 2022), assessing the environmental impact of the same shift, air-HSR competition from the viewpoint of air pollution (incl. GHG) (D'Alfonso et al., 2016, pp. 264-265), intramodal and intermodal price competition (Abrate et al., 2016), studying intermodal airline-HSR cooperation based on its strategic formation and its effects on both consumer surplus and social welfare (Avenali et al., 2018), providing arguments for sustainable aircraft instead of HSR, evaluating the position of HSR compared to further competitive alternative travel modes (e.g. individual four-wheelers amongst light vehicles) (Borsati & Albalate, 2020), investigating the opportunity represented by electric carsharing in the electro-mobility chain at HSR stations, implications of market interventions on the supply side of HSR (e.g. making use of differentiation and targeting new consumer segments, the impact of additional alternative service providers on the same route) (Brenna, 2024), estimating elasticities of HSR demand,

6. **long-distance international rail**: comparing passengers' requirements between night trains and aeroplanes (Kantelaar et al., 2022), projecting future scenarios for sustainable long-distance travel, the worthwhileness of travel time in long-distance trips, influencing factors of medium- and long-distance travel by rail compared to car (Limtanakool et al., 2006, pp. 397-401),
7. **sustainable youth tourism**: exploring the holiday behaviour and motivations, clustering young people based on their attitudes towards sustainable coastal and marine tourism (Forleo & Bredice, 2025).

This study aims at addressing the following research question based on the experience gained in Germany: what are the enablers of opting for rail as a travel mode for domestic or international holiday travels that can be utilised by railway operators?

Data collection

Internationalising higher education is a bidirectional process through mutual inflows and outflows amongst countries. One of its spectacular examples is the University of Passau in Germany having an international student ratio of

16%. In the spring semester of the academic year 2024/2025, 85% of its international students stemmed from 36 countries. Its five faculties cover a wide spectrum of higher education: Law, Social Sciences and Education, Humanities and Cultures (incl. theology), Economics, Informatics and Mathematics (Uni Passau, 2025). Past values are similar. By virtue of an anonymous survey, the data collection took place between 9 and 26 July 2024 in Passau in the circle of individuals aged 18–34 years primarily at its university. Education level was not amongst the questions, nonetheless, acquired tertiary degree or partaking currently in tertiary education in most cases can

Table 1. Classification of countries

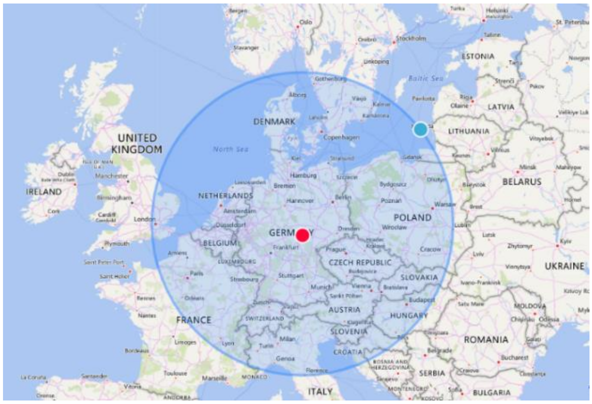
Geographical/geopolitical unit	List of countries
DACH region	Austria, Germany, Switzerland
Benelux	Belgium, Luxembourg, Netherlands
Nordic countries	Denmark, Finland, Iceland, Norway, Sweden
Baltic states	Estonia, Latvia, Lithuania
UK-Ireland	Ireland, UK
Visegrád Group (V4)	Czechia, Hungary, Poland, Slovakia
South-western Europe	France, Italy, Malta, Portugal, Spain
South-eastern Europe	Albania, Bulgaria, Croatia, Cyprus, Greece, Montenegro, Romania, Serbia, Slovenia, Turkey
Within an 800 km radius of Erfurt[4]	Austria, Belgium, Croatia, Czechia, Denmark, France, Germany, Hungary, Italy, Luxembourg, Netherlands, Poland, Slovakia, Slovenia, Sweden, Switzerland, UK
Commonwealth of Independent States (CIS)	Azerbaijan, Belarus, Russia
Middle East	Dubai, Israel, Lebanon, Syria
East and Southeast Asia	China, Japan, Vietnam
North Africa	Egypt, Morocco, Tunisia
Sub-Saharan Africa	Ghana, South Africa, Tanzania, Togo
North America	Canada, Central America, Jamaica, Mexico, USA
South America	Argentina, Bolivia, Paraguay, Peru
Australia	Australia

be assumed. The ability to skip questions was ensured by applying the "no answer, I do not know" (NA) option. The free-to-download dataset contains

[4] Erfurt was assumed to be one of the largest cities in the proximity of the geographical centre of Germany.

179 records. Passau is a stop of DB ICE, DB IC, and ÖBB Nightjet trains affected by lines with high-speed routes. (DB Bahnhof, 2024) In order to reduce the number of countries of destination to a manageable quantity, a few relatively homogeneous country groups were introduced as shown in Table 1 and Figure 1. It was not distinguished between HSR and conventional rail.

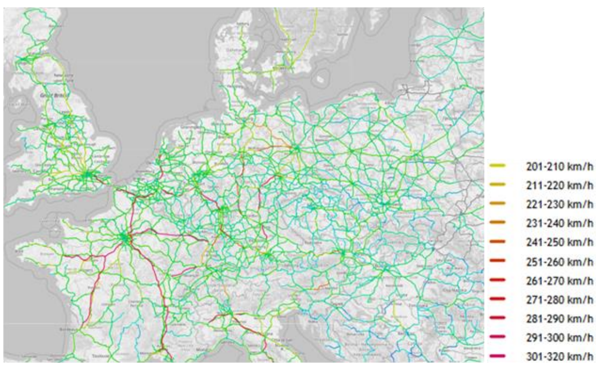
Figure 1. Potential relevant countries available by rail within an 800 km radius of Erfurt (red circle)



(CalcMaps, 2015)

Figure 2 shows the main operational conventional and high-speed rail lines within the same radius of Erfurt.

Figure 2. Railway infrastructure, legend of HSR operating speed[5], status: 03.10.2025



(*OpenRailwayMap, 2025*)

[5] Green and blue colours symbolise conventional rail.

The survey was conducted by relying on a questionnaire related to selected factors assumed to influence the choice of travel mode in favour of trains. The original questions and the answers are detailed in a modified and aggregated manner in Table 2.[6]

Table 2. Set of the transformed variables with distributions (n=179)

Introduced variables (bold font type), assigned values (italic font type), and distribution of answers		
Being_male: *woman=0 [59%], man=1 [41%].*		
Being_younger: *18-24 years=1 [73%], 25-34 years=0 [27%].*		
Denomination of travel modes	*Used=1*	*Not used=0*
Active_routine_mobility (walking, traditional bicycle)	*86%*	*14%*
Environmentally_friendly_passive_routine_mobility (public vehicles, hybrid four-wheeler, electric four-wheeler/motorcycle/scooter/bicycle)	*70%*	*30%*
Not_environmentally_friendly_passive_routine_mobility (traditional four-wheeler/motorcycle/scooter)	*50%*	*50%*
Public_transport	*66%*	*34%*
Car	*54%*	*46%*
Bicycle	*49%*	*51%*
Motorcycle_scooter	*8%*	*92%*
Potential_future_use_of_shared_vehicles[7]	*31%*	*69%*
Current_use_of_shared_vehicles	*20%*	*80%*
Potential_future_use_of_shared_four-wheelers	*27%*	*73%*
Current_use_of_shared_four-wheelers	*16%*	*84%*
Potential_future_use_of_shared_two-wheelers	*14%*	*86%*
Current_use_of_shared_two-wheelers	*6%*	*94%*
Rather_plant-based_nutrition: *rather plant-based=1 [30%], balanced or rather animal-based=0 [69%], NA [1%].*		
Best_energy_and_water_use_at_home: *saving–efficiency–renewables=1 [36%], moderate level or excessive use–fossil energy=0 [64%].*		
Moderate_energy_and_water_use_at_home: *moderate level=1 [57%], rest=0 [43%].*		

[6] Alterations from a total of 100% are due to rounding.

[7] The ratio was estimated based on the question of whether shared four- or two-wheelers at railway stations should be ensured for a higher demand for international high-speed trains, then, this preliminary ratio was complemented with the current users by taking the union.

Destinations of holiday travels in the last 12 months[8]	*Yes=1*	*No=0*
Europe_H (inclusive Turkey, without CIS)	*95%*	*5%*
not_Europe_H (without Turkey, inclusive CIS)	*25%*	*75%*
DACH_region_H	*83%*	*17%*
Benelux_H	*12%*	*88%*
Nordic_countries_H	*10%*	*90%*
Baltic_states_H	*3%*	*97%*
UK-Ireland_H	*9%*	*91%*
V4_H	*28%*	*72%*
South-western_Europe_H	*59%*	*41%*
South-eastern_Europe_H	*26%*	*74%*
800km_radius_Erfurt_H	*92%*	*8%*
Asia_H (inclusive CIS)	*9%*	*91%*
Africa_H	*8%*	*92%*
America_H	*8%*	*92%*
Australia_H	*1%*	*99%*
CIS_H	*2%*	*98%*
Middle_East_H	*3%*	*97%*
East_and_Southeast_Asia_H	*4%*[9]	*96%*
North_Africa_H	*5%*	*95%*
Sub-Saharan_Africa_H	*3%*	*97%*
North_America_H	*7%*	*93%*
South_America_H	*1%*	*99%*

Travel modes for holiday travels[10]	*Used=1*	*Not used=0*
Train_H	*75%*	*25%*
Aeroplane_H	*68%*	*32%*
Ship_H	*6%*	*94%*
Coach_H	*22%*	*78%*
Any_car_H	*58%*	*42%*
Bicycle_H	*8%*	*92%*
Environmentally_friendly_public_vehicles_H (train, coach)	*78%*	*22%*
Not_environmentally_friendly_public_vehicles_H (aeroplane, ship)	*70%*	*30%*

[8] 176 individuals had at least 1 holiday travel (see the variable Holiday_travel_min_1) in the last 12 months, but the proportions are calculated by dividing with the initial sample size of 179.

[9] 1 respondent indicated Asia without more precise details as one of the destinations. This case is included here.

[10] Again, 179 is in the denominator. 2 out of 179 participants made use of caravan and 1 person of motorcycle. They are ignored.

Destinations of business travels in the last 12 months[11]	*Yes=1*	*No=0*
Europe_B (inclusive Turkey, without CIS)	*25%*	*75%*
not_Europe_B (without Turkey, inclusive CIS)	*2%*	*98%*
DACH_region_B	*21%*	*79%*
Benelux_B	*1%*	*99%*
Nordic_countries_B	*1%*	*99%*
UK-Ireland_B	*2%*	*98%*
V4_B	*4%*	*96%*
South-western_Europe_B	*3%*	*97%*
South-eastern_Europe_B	*1%*	*99%*
800km_radius_Erfurt_B	*24%*	*76%*
CIS_B	*1%*	*99%*
North_America_B	*2%*	*98%*

Travel modes for business travels[12]	*Used=1*	*Not used=0*
Train_B	*21%*	*79%*
Aeroplane_B	*5%*	*95%*
Ship_B	*1%*	*99%*
Coach_B	*3%*	*97%*
Any_car_B	*7%*	*93%*
Bicycle_B	*1%*	*99%*
Environmentally_friendly_public_vehicles_B (train, coach)	*22%*	*78%*
Not_environmentally_friendly_public_vehicles_B (aeroplane, ship)	*5%*	*95%*

Factors when evaluating HSTs compared to aeroplanes and/or own traditional four-wheelers	*HSTs are preferred=1*	*HSTs are not preferred=0*	*NA*
Travel_cost_HST	*64%*	*28%*	*8%*
Travel_time_HST	*65%*	*27%*	*7%*
Safety_avoiding_accidents_HST	*71%*	*17%*	*12%*
Delays_technical_troubles_HST	*29%*	*60%*	*11%*
Comfort_HST	*73%*	*19%*	*8%*
Hygiene_HST	*46%*	*43%*	*11%*
Privacy_HST	*41%*	*46%*	*13%*
Moving_with_luggage_HST	*65%*	*28%*	*7%*
Emissions_impact_HST[13]	*84%*	*9%*	*7%*

[11] 44 observations demonstrated business trips (see the variable Business_trip_min_1). The distributions are projected to 179. The exact travel numbers in the sample are not known. However, it can be assumed that the share of business trips in total travel in the target group is higher than in the whole population.

[12] Likewise, 179 is in the denominator of the quotients.

[13] Major air pollutants and GHGes are CO_2, NO_x, SO_x, and particulate matter. (*HCSO, 2024*)

Flexibility_HST[14]	*49%*	*44%*	*7%*
Technology_HST	*57%*	*26%*	*17%*

Factors when evaluating coaches[15] compared to aeroplanes and/or own traditional four-wheelers	*Coaches are preferred=1*	*Coaches are not preferred=0*	*NA*
Travel_cost_coach	*79%*	*15%*	*7%*
Travel_time_coach	*28%*	*66%*	*6%*
Safety_avoiding_accidents_coach	*34%*	*47%*	*19%*
Delays_technical_troubles_coach	*35%*	*51%*	*15%*
Comfort_coach	*28%*	*59%*	*12%*
Hygiene_coach	*25%*	*61%*	*13%*
Privacy_coach	*24%*	*66%*	*9%*
Moving_with_luggage_coach	*55%*	*33%*	*12%*
Emissions_impact_coach	*62%*	*26%*	*12%*
Flexibility_coach	*37%*	*55%*	*8%*
Technology_coach	*23%*	*55%*	*21%*

Variables related to voluntary carbon offsets (VCOs)[16]	*Yes=1*	*No=0*
Known_notion	*83%*	*17%*
VCOs_used (occasionally or rather always)	*29%*	*71%*
Higher_frequency_VCOs (rather always)	*4%*	*96%*
Striving_towards_net_zero_GHG_emissions_during_mobility (green modes without VCOs and less green modes coupled with VCOs)[17]	*8%*	*92%*

[14] Flexibility options encompass inter alia timetables, transfers, and ticket purchase.

[15] The rationale for indicating the comparison regarding coaches was the proliferation of multimodal companies operating in both the long-distance train and coach market such as DB, Flix, and the Group MÁV-Volán. The results point to the dissimilarities in the evaluation between HSTs and coaches when they are compared to alternative vehicles with higher GHG emission intensity. Based on the independent-samples proportions z-test, HSTs outperform coaches in all investigated dimensions apart from two aspects. Coaches have a significant competitive advantage in travel cost (one-sided p-value=0.12%); however, the difference is not significant with respect to possible delays and technical troubles (one-sided p-value=12.83%). Without underpinning the statement in connection with travel cost, it is closer to the reality to claim based on a quick online comparison that the range of ticket prices of HSTs (DB) includes that of coaches (FlixBus).

[16] The precise distribution is: unknown notion [16%], known but not used [54%], not applicable [1%], used occasionally [25%], and used rather always [4%]. It is worth noting that not only passengers of transport companies can make use of VCOs. For CO_2 emissions arising from car usage during daily commuting can be compensated as well.

[17] It was assumed that an individual strives towards net zero GHG emissions during mobility if (i) he/she opts for active routine mobility, passive environmentally friendly routine mobility, or train for holiday travels or business trips. (ii) Additionally, even if

Travelling_with_companions_for_holiday: *Yes=1 [90%], No=0 [10%].*	
Rail_is_the_most_preferred_transport_mode (in the case of international travels): *Yes=1 [34%], No=0 [66%][18], NA [1%].*	

Areas to be improved for a higher demand for international HSTs	*Yes=1*	*No=0*
More_destinations_desired	*53%*	*47%*
More_frequent_connections_desired	*64%*	*36%*
Fewer_delays_or_technical_troubles	*88%*	*12%*
New_railway_carriages	*12%*	*88%*
Less_travel_time (thanks to higher speed)	*59%*	*41%*
Price_building (e.g. more low-cost offers)	*82%*	*18%*

Marketing measures related to international HSTs	*Yes=1*	*No=0*
Recommendation_system[19]	*32%*	*68%*
Free_transferable_tickets[20]	*71%*	*29%*
Loyalty_programme_size_discounts[21]	*58%*	*42%*
Loyalty_programme_frequency_discounts[22]	*51%*	*49%*
Loyalty_programme (size or frequency discounts)	*78%*	*22%*
Offers_from_partner_companies[23]	*42%*	*58%*

Rather_active_traveller:
rather active=1 [29%], balanced or rather passive=0 [56%+15%=71%].

Common category[24]	*Count*	*Mean*	*Standard deviation*
Infrastructure_HST[25]	*178*	*0.6096*	*0.3125*
Rolling_stock_HST[26]	*179*	*0.5789*	*0.2450*

he/she makes use of not environmentally friendly vehicles for routine mobility, or of aeroplane, ship, coach, or car for holiday travels or business trips, the arising GHG emissions are counterbalanced through VCOs used rather always.

18 The striking value of the weight of less environmentally friendly modes in the indicator would call for their urgent decarbonisation.

19 E.g. automatically receiving benefits after a new customer made purchases online upon recommendation.

20 Providing free and transferable tickets for existing customers e.g. switch option to a higher class by means of rail upgrade tickets.

21 Depending on the cumulated total amount of purchases in the last 12 months.

22 Depending on the number of different destinations in the last 12 months.

23 Services may encompass e.g. accommodation, shared bicycle, carsharing, private car rental, travel insurance, and sightseeing tours.

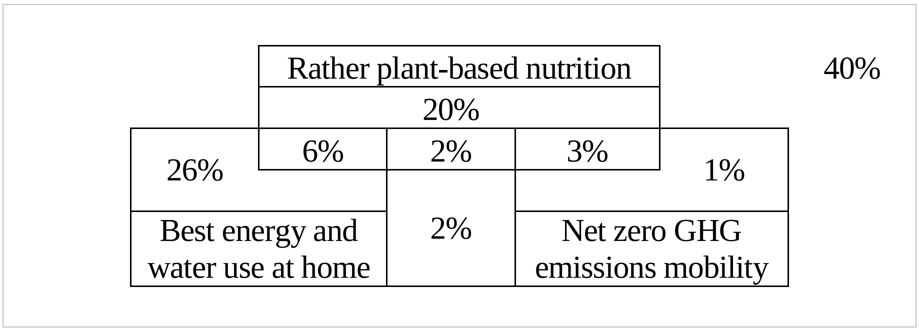
24 Due to the relatively high share of missing values, a part of the predictors is unified into common categories by utilising the formula below:
$\frac{\sum_{i\in\mathcal{H}} Variable(i)}{n(\mathcal{H})}$, where $\mathcal{H}$ is the set of variables responded, and $n(\mathcal{H})$ is the cardinality of the set $\mathcal{H}$.

25 Infrastructure is the average of the sum of three variables: Travel_time_HST, Safety_avoiding_accidents_HST, and Delays_technical_troubles_HST.

26 Rolling stock unifies Comfort_HST, Hygiene_HST, Privacy_HST, Moving_with_luggage_HST, and Emissions_impact_HST by virtue of their mean.

The responses to the questionnaire enable us to estimate the distribution according to three main components of the ecological footprint, i.e. food, energy and water use at home, and any kind of mobility (commuting, holiday and business travels). Figure 3 is a simplified representation by relying on rather plant-based nutrition[27], best energy and water use at home, and striving towards net zero GHG emissions in the field of mobility (commuting, holiday travels, and business trips).

Figure 3. Distribution of the sample along the dimensions and levels of environmental consciousness (n=179)



Amongst the three investigated dimensions, mitigating energy and water use at home can be considered as the easiest implementable or the most important area. Nutrition demonstrates less willingness. Achieving net zero GHG emissions regarding mobility is hardly stand-alone and requires the most effort and resources from the individuals. The triple intersection indicates the estimated current share of individuals fit for climate neutrality: at the most 2% of the sample.

Data analysis

Quantitative analyses were carried out in the statistical software IBM SPSS Statistics Version 29 and Microsoft Excel. Independent-samples proportions z-tests were performed to compare proportions. The t-test based on skewness helped in judging the symmetricity of a distribution. Asymptotic independent-samples z-tests were used for testing the equality of means. Both probit analysis and binary logistic regression were appropriate for binary classification.

[27] Organic and seasonal food or minimising food waste and GHG emissions arising from food transport are ignored influencers.

If the condition of min[n·p,n·(1-p)]≥10 is met and the null hypothesis of the independent-samples proportions z-test is $H_0: p_Y - p_X = 0$, then the test can be computed by dint of the weighted proportion $\bar{p}$ as (*Hunyadi et al., 2000, pp. 453, 470*):

$$\bar{p} = \frac{n_X \cdot p_X + n_Y \cdot p_Y}{n_X + n_Y} \qquad /1/$$

$$Z = \frac{p_Y - p_X}{\sqrt{\bar{p} \cdot \bar{q} \cdot (\frac{1}{n_X} + \frac{1}{n_Y})}} \to N(0,1) \qquad /2/$$

The t-test of symmetric distribution based on skewness is an appropriate tool for controlling the fulfilment of the prerequisite regarding large samples for the asymptotic independent-samples z-test. The test applied to check symmetric distribution is based on the quotient of the skewness and its standard error (following Student's t-distribution with the number of degrees of freedom equalling n-1) (Kovács, 2014, p. 6):

$$T = \frac{\sum_{i=1}^{n} (x_i - \bar{x})^3}{s^3} \cdot \frac{n}{(n-1) \cdot (n-2)} \Big/ \sqrt{\frac{6 \cdot n \cdot (n-1)}{(n-2) \cdot (n+1) \cdot (n+3)}} \qquad /3/$$

A symmetric distribution reduced the sample size necessary to qualify as a large sample to 30 observations, else, the rule of thumb was a minimum of 100 observations. The asymptotic independent-samples z-test (requiring large samples) (Hunyadi et al., 2000, pp. 283, 468-469):

$$Z = \frac{\bar{y} - \bar{x}}{\sqrt{\frac{s_X^2}{n_X} + \frac{s_Y^2}{n_Y}}} \to N(0,1) \qquad /4/$$

Probit analysis (IBM, 2016, pp. 797-801) applies the cumulative distribution function of the standard normal distribution. The expected response $\hat{y}$:

$$\hat{y} = \Phi\left(\hat{\beta}_0 + \sum_{i=1}^{m} \hat{\beta}_i \cdot x_i\right) = \Phi\left(\underline{\hat{\beta}}^T \cdot \underline{x}\right) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\underline{\hat{\beta}}^T \cdot \underline{x}} e^{-\frac{z^2}{2}} dz \qquad /5/$$

By denoting the sample size with n and the number of degrees of freedom ν=n-m-1, the Pearson goodness-of-fit test is a right-tailed chi-square test:

$$\chi^2 = \sum_{j=1}^{n} \frac{(y_j - \hat{y}_j)^2}{\hat{y}_j \cdot (1 - \hat{y}_j)} \qquad /6/$$

Binary logistic regression (IBM, 2016, pp. 557-566) applies the logit transformation of the probability:

$$logit\ p(\underline{x}) = ln\left[\frac{p(\underline{x})}{1-p(\underline{x})}\right] = ln(odds) = \underline{\hat{\beta}}^T \cdot \underline{x} \qquad /7/$$

$$p(\underline{x}) = \frac{\exp\left(\underline{\hat{\beta}}^{\mathrm{T}} \cdot \underline{x}\right)}{1+\exp\left(\underline{\hat{\beta}}^{\mathrm{T}} \cdot \underline{x}\right)} \qquad /8/$$

The Hosmer and Lemeshow goodness-of-fit statistic is the next right-tailed chi-square test:

$$\chi^2_{HL} = \sum_{k=1}^{g} \frac{(O_{1k}-E_{1k})^2}{E_{1k} \cdot \left(1-\frac{E_{1k}}{N_k}\right)} \qquad /9/$$

Concerning the k^{th} group, O_{1k} and E_{1k} symbolise the number of observed cases with y=1 and that of expected cases with y=1, furthermore, N_k stands for the total number of observations (both y=0 and y=1), and their sum is equal to the final sample size n. The number of degrees of freedom is ν=g-2.

Testing the null hypothesis of zero beta coefficients relies on the z^2 distribution, which is a chi-square distribution with the number of degrees of freedom equalling 1 and k=0, 1, …, m:

$$Wald_k = \frac{\hat{\beta}_k^2}{s^2_{\hat{\beta}_k}} \qquad /10/$$

Findings

The sample can be divided into two subsets in such a way that one of them includes those travelling by train (135 persons), while the rest (44 participants) constitute the other. The rule of thumb of a minimum of 10 expected observations is not met in numerous cases due to the low subsample sizes. For this reason, the results are bifurcated into two classes:

(A) met rule of thumb with a minimum of 10 expected observations and significant difference at a one-sided significance level of 10%,

(B) unmet rule of thumb but significant difference.

Table 3 outlines 17 significant factors not necessitating financial expenditures from the side of the railway operators.

Table 3. Results of the independent-samples proportions z-tests – attributes without financial implications

Variable	Rule of thumb	Proportion for		z-test	One-sided p-value
		train users	train avoiders		
Environmentally_friendly_ passive_routine_mobility=1	(A)	76%	55%	2.6511	0.40%
Public_transport=1	(A)	71%	50%	2.5658	0.51%
Current_use_of_shared_two-wheelers=1	(B)	4%	11%	1.6597	4.85%
Not_environmen-tally_friendly_passive_rou-tine_mobility=1	(A)	43%	73%	3.4293	0.03%
Car=1	(A)	47%	75%	3.1902	0.07%
Rather_plant-based_nutrition=1	(B)	34%	19%	1.9484	2.57%
Europe_H=1	(B)	97%	89%	2.2146	1.34%
not_Europe_H=1	(A)	22%	32%	1.2839	9.96%
800km_radius_Erfurt_H=1	(B)	95%	84%	2.3007	1.07%
DACH_region_H=1	(A)	89%	66%	3.5442	0.02%
Benelux_H=1	(B)	14%	5%	1.7057	4.40%
V4_H=1	(B)	31%	18%	1.6600	4.85%
Coach_H=1	(B)	25%	11%	1.9288	2.69%
Bicycle_H=1	(B)	10%	2%	1.5784	5.72%
Any_car_H=1	(A)	53%	73%	2.2643	1.18%
Train_B=1	(B)	24%	9%	2.1842	1.45%
VCOs_used=1	(B)	32%	20%	1.4462	7.41%

Those opting for trains for holiday travels rely more on environmentally friendly (e.g. public transport, shared two-wheelers) and less on not eco-friendly vehicles (e.g. traditional cars) for their passive routine mobility. Amongst them, a higher share consumes rather plant-based food. Their target countries are more often located in Europe and less likely outside the continent. The assumption related to the rail ceiling represented by the radius of 800 km can be accepted. Amongst the more precise destinations, the DACH, Benelux, and V4 countries are more preferred. They make more use of both coach and bicycle, but car is less typical during their holiday travels. They are more likely to prefer train for business trips as well. They offset their CO_2 emissions with a higher probability than the train avoiders.

Table 4 recapitulates 12 binary variables coupled with investment or cost or revenue reduction for the railway operators. Table 5 is an analogous sheet related to scale variables with appropriate tests.

Table 4. Results of the independent-samples proportions z-tests – attributes with possible financial implications

Variable	Rule of thumb	Proportion for		z-test	One-sided p-value
		train users	train avoiders		
Travel_time_HST=1	(A)	75%	57%	2.1929	1.42%
Delays_technical_troubles_HST=1	(B)	38%	15%	2.7286	0.32%
Comfort_HST=1	(A)	82%	71%	1.4490	7.37%
Hygiene_HST=1	(A)	57%	36%	2.2964	1.08%
Privacy_HST=1	(B)	58%	16%	4.4920	0.00%
Moving_with_luggage_HST=1	(A)	77%	46%	3.5997	0.02%
Flexibility_HST=1	(A)	63%	26%	4.1869	0.00%
Rail_is_the_most_preferred_transport_mode=1	(B)	38%	21%	2.0353	2.09%
New_railway_carriages=1	(B)	14%	5%	1.7057	4.40%
Loyalty_programme_size_discounts=1	(A)	62%	43%	2.2191	1.32%
Loyalty_programme_frequency_discounts=1	(A)	56%	34%	2.5587	0.53%
Loyalty_programme=1	(A)	82%	66%	2.2765	1.14%

Table 5. Results of the t-tests of symmetric distribution based on skewness and the asymptotic independent-samples z-tests

Variable	Infrastructure_HST		Rolling_stock_HST	
User type	Train users	Train avoiders	Train users	Train avoiders
Count	134	44	135	44
Skewness	---	0.0035	---	0.3175
Standard error of skewness	---	0.3575	---	0.3575
Prerequisite for being a large sample	above 100 observations	n>30 and symmetric distribution (2-sided p=99.21%)	above 100 observations	n>30 and symmetric distribution (2-sided p=37.93%)
Mean	0.6393	0.5189	0.6270	0.4311
Standard deviation	0.3074	0.3138	0.2294	0.2345
z-test	2.2187		4.8399	
One-sided p-value	1.33%		0.00%	

Users of trains for holiday travels evaluate a few attributes of HSTs more favourably. These are travel time, possible delays or technical troubles, comfort, hygiene, privacy, moving with luggage, and flexibility. This applies to both common categories (infrastructure and rolling stock) as well. In their circle rail ranks better as the most preferred travel mode for making international travels. Oddly, even if new railway carriages would operate, a slight proportion of train avoiders would opt for rail. Proponents of rail would welcome loyalty programmes with a higher probability in order to benefit from either size or frequency discounts.

For determining the enablers and disablers for the railway operators, the probit analysis proved to be an appropriate technique accompanied by the binary logistic regression as an alternative method with the purpose of reinforcement. In each run, the dichotomous dependent variable Train_H was investigated to reproduce the choice for the travel mode rail. The probit analysis was carried out in such a way that, first, the enter method was applied by relying on the initial circle of independent variables listed in Tables 3, 4, and 5. Second, the run was repeated by removing for each occasion the least significant predictor and keeping the enter method. The loop terminated when the model contained solely significant beta coefficients at the significance level of 10% disregarding the intercept. In addition, the results had to be reasonably interpretable. Of the many models run, the two final ones show the most favourable overall correct classification rates by using the indicated cut value[28]. Afterwards, the final probit runs formed the basis of the logit models by keeping the enter method.

Table 6 summarises the main results of the final probit and logit models concerning the attributes without financial implications. The initial set of independent variables contained 17 variables. The constant is by default included in the probit equations in SPSS, but the intercept was considered zero as the corresponding null hypothesis cannot be rejected (β_0=-0.0370, p-value=89.24%).

[28] By striving to find the cut value that is the closest to 0.5, the rule of dividing the observations into two groups indexed by 0 (train avoiders) and 1 (train users): if probability<cut value, then, 0, else, 1.

Table 6. Results of the probit and logit models without financial implications

Denomination		Probit model		Logit model	
Type of goodness-of-fit test with p-value		Pearson: 52.03%[29]		Hosmer and Lemeshow: 96.03%	
Final sample size		177		177	
Number of regressors in the final model		6		6	
Cut value		0.51		0.51	
Correct classification rates	Total	139/177=78.53%		139/177=78.53%	
	Related to y=0	12/43=27.91%		13/43=30.23%	
	Related to y=1	127/134=94.78%		126/134=94.03%	
Variable		Beta	p-value	Beta	p-value
Rather_plant-based_nutrition		0.5315	5.64%	0.8628	6.85%
DACH_region_H		1.1296	0.01%	1.9009	0.00%
Bicycle_H		1.0749	6.26%	1.9300	8.26%
Any_car_H		-0.9172	0.08%	-1.6227	0.07%
Train_B		0.7113	2.73%	1.2868	2.93%
VCOs_used		0.4595	9.78%	0.7275	12.51%

Rather plant-based nutrition, travelling in DACH countries for holidays (mostly domestic destinations), relying on bicycle as a transport mode during holidays, selecting rail for business trips, and past experience with offsetting CO_2 emissions are promoters of opting for train. In contrast, making use of any kind of car for holiday travels is weakening the position of rail. In both models, the total correct classification rate is 78.53% and the true positive rate (i.e. sensitivity) is above 94%. However, both partial correct classification rates related to train avoiders (i.e. specificity) remain below 31%. Consequently, these models can only be considered apt for classifying train users. Irrespective of the method, the coefficients of the predictors have the same sign and similar relative weights, nonetheless, the beta parameter of VCOs_used lost significance in the logit model. Regarding causality, the endeavour of mitigating the GHG emissions and/or the ecological footprint in the field of food (rather plant-based) and energy use during mobility (preferring bicycle, renouncing car, and compensating for CO_2 emissions), furthermore, the close destination can explain the use of rail as an environmentally friendly and easily available transport mode. With respect to business trips made by rail, a mutual relationship can be assumed.

[29] The p-value was recalculated for the case without intercept. The model with constant included had a p-value of 61.76%.

Regarding the variables related to possible financial implications, the probit analysis on the original variables (see Table 4) did not provide any reasonable models. For this reason, replacing them with the introduced two common categories was necessary. Table 7 elucidates the significant influencing factors by applying a significance level close to 10%.

Table 7. Results of the probit and logit models with financial implications

Denomination		Probit model		Logit model	
Type of goodness-of-fit test with p-value		Pearson: 54.16%		Hosmer and Lemeshow: 58.39%	
Final sample size		166		166	
Number of regressors in the final model		3		3	
Cut value		0.46		0.45	
Correct classification rate	Total	129/166=77.71%		129/166=77.71%	
	Related to y=0	13/43=30.23%		13/43=30.23%	
	Related to y=1	116/123=94.31%		116/123=94.31%	
Variable		Beta	p-value	Beta	p-value
Flexibility_HST		0.7609	0.15%	1.2950	0.22%
Loyalty_programme		0.4355	10.64%	0.7610	9.79%
Rolling_stock_HST		1.5913	0.12%	2.7086	0.15%
Intercept		-0.8811	0.71%	-1.5262	0.71%

Interestingly, infrastructure does not play a significant role in the choice of train for holiday travels, therefore, transport infrastructure development cannot per se form the bedrock of the use of rail for holiday travels. The positive evaluation of the rolling stock (in terms of comfort, hygiene, privacy, moving with luggage, and emissions impact) can give the largest impetus followed by flexibility. Providing loyalty discounts can exercise a supporting effect but its significance is doubtful at the level of 10%. Despite the acceptable total correct classification rates (77.71%), the high rates of false positive classifications mean that the expected classification provided by these models for the train avoiders is weak. The model comparison points out that the beta parameters demonstrate identity or resemblance of high degree in terms of sign, relative weight, and significance. Agreeing with the rail advancements achieved in the field of comfort, hygiene, privacy, moving with luggage, emissions impact, and flexibility can imply a mobility attitude favouring trains instead of aeroplanes or cars. Benefitting from possible loyalty discounts as a cause can improve the evaluation of rail offers.

Discussion

Regarding the influencing factors arising from the analysis, the authors of preceding studies have made partly confirming and partly refuting findings.

Rather_plant-based_nutrition: In Italy, Castellini et al. (2023, p. 4) pointed to a significant positive correlation between sustainable food consumption (not identical with rather plant-based nutrition but a presumed noteworthy intersection does exist) and sustainable mobility (+0.37).

DACH_region_H: With regards to the countries of destination, *Avogadro et al.* (2021, p. 32) estimated the share of both domestic and international airline seats potentially replaceable by rail as a monotone increasing function of the increment in travel time[30] as a consequence of the switch from air to rail. With particular reference to the German domestic market, the degree of the air-to-rail substitutability reaches 70% if passengers are inclined to accept an at most 50% increase in travel time. Additionally, international routes (such as those related to the Benelux states or France) are also touched by a possible modal shift. Reiter et al. (2022, pp. 2028-2029) pointed to the potentially replaceable seat capacity at German airports (e.g. Munich, Frankfurt am Main) by assuming that the threshold of travel time for using the rail alternative in the context of air-HSR competition is maximum 6 hours. This duration may concern not only all DACH countries but destinations in Benelux, France, Czechia, or Poland as well depending on the departure airport. It can be assumed that due to the geographical location of Passau, neither the Benelux nor the V4 are amongst the predictors with a significant beta coefficient.

Bicycle_H: The sample suggests that rail and bicycle are tightly interconnected in the sense that opting for bicycle during holiday travels implies the use of rail. This independent variable demonstrated the highest positive beta coefficient after the close country of destination. Maltese & Zamparini (2023, pp. 4-6) highlighted based on a survey conducted in the circle of students in Milan that the time share of sustainable mobility (walking, cycling, and public transport) at holiday destinations is positively determined by both the same time share at home and the use of train to reach the tourist destinations.

Any_car_H: Borsati & Albalate (2020, p. 157) found in Italy that available HSR services did not result in a road-to-rail modal shift when investigating road transport represented by light vehicles. This non-competing

[30] The travel time includes in addition to the in-vehicle time further components (e.g. departure waiting time).

nature between the two transport modes underpins the negative beta coefficient of H_any_car. Limtanakool et al. (2006, p. 401) elucidated that women engage less likely in medium- and long-distance leisure trips made by car as a transport mode. The German sample reinforces this finding as the proportion of those using car for holiday travels is higher for males (66%) than for females (52%).

Train_B: A search for Open Access articles arising from preceding research on the Web of Science did not yield any results.

VCOs_used: Concerning domestic electrified rail lines, both DB and ÖBB achieved carbon neutrality due to 100% green electricity in use since 2018. (DB, 2025b; ÖBB, 2025) For this reason, VCOs explain the selection for rail, and they are more likely to affect other transport modes with GHG emissions such as coach, car, or aeroplane. The selected previous studies scrutinised the enablers and disablers of VCOs; however, not the causal linkage between VCOs and the use of rail. Cordes et al. (2024, p. 13) collected based on an extensive literature review the factors influencing the willingness to pay for aviation VCOs. Positive effects can be attributed to young age (see the ratio of 29% for VCOs used in Table 2), being highly educated, awareness of aviation's emissions contribution (in this study, see the emissions impact of HSTs and coaches arising from possible comparisons with aeroplanes in Table 2: the shares are 84% and 62%, respectively), and applying a low price for VCOs (see the successful practice of coach companies[31]). Gender plays no role (in the German sample, the proportions of those making use of VCOs are 27% for males and 30% for females). Travel occasions due to business reasons (based on the dataset, this cannot be judged) and highly-priced VCOs (the practice of air companies may provide an explanation in the case of distant locations: 1 out of 14 respondents flying in Asia /incl. CIS/ compensated for VCOs) are hindrances. With limited scope, Rotaris et al. (2020, pp. 79, 82) examined the willingness to pay for VCOs in the circle of air travellers in Italy. The analysis elucidated that flying frequently, having business flights, and being male reduce proneness, while environmental consciousness and being more educated and employed/student are positive determinants.

Flexibility_HST and Rolling_stock_HST: Albeit the present study applies an intermodal comparison (train versus aeroplane or own traditional four-wheelers), Güner et al. (2024, pp. 830, 836-837) found along overlapping

[31] Compared to flights, compensating for CO_2 emissions during a ride by coach is low in absolute value. FlixBus enables its passengers to pay usually approximately 1-3% in addition to the original travel price as a VCO. (FlixBus, 2025)

categories related to rolling stock and flexibility that the importance attributed to service dimensions dropped (apart from tangibles) and the perceived service quality ameliorated when carrying out their temporal investigation for conventional rail. In contrast, passengers of HSR are evaluating the particular attributes more ambivalently. For this reason, it can be assumed that posing more moderate importance but experiencing a better quality in its entirety improved the position of rail compared to the two alternative modes.

Loyalty_programme: Related to attitudes to long-distance travel and HSR, Harvey et al. (2014, pp. 72-74) pointed to differences by gender and the possession of a travel discount. The first variable proved to be not significant in the analyses, while the latter one gains reinforcement in the form of loyalty programmes offering discounts.

Conclusion, limitations, and further research

The findings suggest that preferring train for holiday travels is likely in the case of rather plant-based nutrition, geographically close destinations (here DACH countries), cycling during holiday travels, having business trips by rail, and a practice of compensating for CO_2 emissions. Travelling by car works in the opposite direction. These non-financial factors can be complemented by financial implications for railway operators such as the positive assessment of both the rolling stock and the flexibility attributed to rail transport, finally, finding rail loyalty programmes appealing. The partial correct classification rates hint at the weakness of both probit and logit models in predicting not using rail.

The results have some limitations. The low sample size (n=179) mitigates the validity of marked results stemming from independent-samples proportions z-tests due to unmet rules of thumb. Participants left out numerous questions or ticked the NA option primarily in the block related to the comparison between HSTs and aeroplanes/own traditional four-wheelers. Subjective interpretation in the case of not exact specifications (e.g. components of the ecological footprint) and alteration from accurate questions (e.g. considering a broader time interval instead of the last 12 months) may cause biases.

Numerous further relevant factors could have been enquired. A few examples affecting service providers are corporate image and customer relations perceived by passengers, brand loyalty (e.g. membership in loyalty programmes), waiting for special offers or promotions, and impressions about employees of transport companies. More trip attributes could have been asked. Visiting a sole main destination or making a round trip, more possible travel purposes in addition to holiday and business travels, barrier-free travel, transport of bicycles, and on-board entertainment options could have ameliorated the quality of findings. It was not discerned amongst transport mode choices to the destination country and at the destination itself. Neither night nor daytime journeys can be identified regarding the timing of the travels in the dataset. Regarding VCOs, assignments between the travel mode and the country are missing. Asking for the precise departure and arrival locations could have rendered it possible to operate with distance ranges instead of country groups.

First, further research may reveal the factors influencing passengers in opting for rail as a travel mode for their business travels by increasing the sample size (only 37 out of 44 respondents having business trips in the sample opted for rail). Second, regarding the market share of holiday travel by fossil fuel four-wheelers and short-haul aeroplanes, a shift towards their substitute represented by rail or its combination with shared electric cars would be desired in order to create public electromobility chains. Future scrutiny may disclose the weaknesses of current rail and carsharing offers not corresponding to consumer preferences.

A possible future sustainable long-distance mobility scenario can rely on four basic pillars represented by environmentally friendly own or shared four-wheelers for individual use, railway transport (increasing share of HSTs operating with 100% green electricity and improved cross-border connections), more environmentally friendly aviation (sustainable aviation fuels, electric), and electric coaches complementing rail services. A modal shift affecting the currently considerable market share of vehicles with high GHG emission intensity (aeroplanes and traditional cars) could substantially alleviate environmental load, allocate residential expenditures on transport towards public transport by ensuring the sources of further development, avoid accidents on roads, improve capacity utilisation of public vehicles, enhance recreational benefits for travellers, foster both the expansion of shared vehicles and more rapid technology adoption in public transport, finally, accelerate the liberalisation of rail passenger transport and the foundation of an efficient interoperable railway system in Europe.

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